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THE FEASIBILITY OF A NATIONAL BIOMECHANICS DATA BANK

Report of Working Group 87

Committee on Hearing, Bioacoustics, and Biomechanics
Assembly of Behavioral and Social Sciences
National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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PREFACE

At the request of the U.S. Air Force, the Committee on Hearing, Bioacoustics, and Biomechanics (CHABA) established Working Group 87 to investigate the feasibility and desirability of organizing a coordinated national effort to collect biomechanical data.

This report represents a summary of the discussions and conclusions of a group of biomechanicians and biomedical scientists who were asked to participate in the working group activity and who are concerned with a problem crucial to the growing national biomechanics effort -- namely, the storage and retrieval of reliable biomechanical data. Specifically, the discussions were focused on the desirability and/or ability to "standardize" the acquisition of data; which would ease the burden of transfer, comparison, and correlation of the data among groups of researchers. Since in this country biomechanical data are generated for the most part through research under the sponsorship of federal agencies, the contract mechanism provides a partial means of ensuring some compliance with the recommendations of the working group, should they be accepted. The need for better communication and exchange of information is critical for a discipline such as biomechanics, for which most of the numerical data have been generated in the past 15 years. Invariably, as a new discipline matures, the need for codification and consolidation emerges quite naturally.

The suggestion for this study orginated with Henning Von Gierke in his summation at the February 1977 Symposium on Biodynamic Models and Their Application in Dayton, Ohio. The proceedings of this symposium was published as a separate section of Aviation, Space and Environmental Medicine (1). Von Gierke stated the case for a biomechanics data bank succinctly:

> ... it appears essential that the material properties and mechanical characteristics fed into the mathematical models be based on all the relevant data available, and not on a few test results from an individual investigator. In view of the time, cost, and risk involved in obtaining this broad spectrum of experimental data, I think consideration should be given to the establishment of some kind of centralized national data bank that would store: a) directly measured mechanical properties of human tissue, b) mechanical properties of tissues

of animals most frequently used in biodynamic research, c) human injury/rupture information derived from accident analysis, d) human tissue/organ response characteristics derived from volunteer biodynamic tests, e) human body dynamic response data from volunteer tests, and f) animal body subcritical and critical response data. This data bank should be fed by all laboratories working in this field and its data should be generally available. In this way, model parameters and inputs could be compared to the best and, above all, to all types of response data available. Such orderly collection of available data will also pinpoint gaps in our knowledge and could define the type and specify the format of data still missing. I propose that the need for such a data bank be seriously discussed by the various organizations and government agencies involved in biodynamic research.

A preliminary meeting was convened in New Orleans on March 22, 1978, with representatives from universities, research institutes, and agencies of the U.S. Department of Transportation (DOT) and the U.S. Department of Defense (DOD). The desirability of establishing a biomechanics data bank was unanimously approved by the participants. A second meeting took place in Chicago on July 31, 1978, at which the participants were formally designated as Working Group 87 of CHABA. A third and final meeting took place in Washington, D. C., on October 16, 1978.

Working Group 87 was divided into three subgroups: (1) materials and compartmental properties, (2) whole-body biomechanic response, and (3) accidents and injuries. Each was requested to consider and expand on the following issues, which are detailed in Part 2 of this report:

(1) The scope and reasonable extent of a national biomechanics data bank;
(2) The nature and selection of the data to be included, e.g., format of submission, selection of the type of experiments, and evaluation of the data;
(3) The data storage and retrieval requirements;
(4) Government agencies, programs, and private institutions interested in and able to deposit and withdraw from the bank; and
(5) The approximate cost of establishing and maintaining the data bank.

Although this report addresses only activities in the United States, it should be obvious that a number of other industrialized nations have substantial government-supported data bases that may be eventually included in such a bank. International collaboration in this area is increasing daily. For example, the International Research Committee for the Study of Kinetics of Impact (IROCOBI) and the International Standards Organization (ISO) could be asked to encourage international cooperation.

It is the hope of Working Group 87 that this report will serve as an initial guide, despite its preliminary nature, to those who take the next step in establishing a biomechanics data bank.

Already several intra-agency data banks have been initiated. In addition, a pilot interagency project involving several members of Working Group 87 has been formed at the request of the U.S. Department of Transportation. However, as of this writing, the transfer of electronic data among the members has not yet begun.

Y. King Liu, Chairman
Working Group 87

REPORT OF THE WORKING GROUP

INTRODUCTION

Biomechanics encompasses the study of any phenomenon in which knowledge of the biomechanical properties of living systems is a prerequisite to understanding, controlling, and predicting the phenomenon. A partial list includes investigation into problems of weight bearing and locomotion, prosthetic development, assisted voluntary motion, performance, physiology, and injury response to different exposures of vibration, impact, sustained acceleration, and mechanical shock.

Two factors have contributed to the interest of Working Group 87 in establishing a national biomechanics data bank. One is that the major source of mortality and morbidity of the young adult population in industrialized nations is due to impact acceleration from vehicular accidents. The second factor is an expanding worldwide effort in laboratories supported by diverse sponsors to develop strategies to reduce mortality and morbidity. One such strategy is the use of protective devices to limit the loads applied to human occupants. The main thrust of efforts for a national biomechanics data bank at this time is toward biomechanical and injury data judged to be important for the reduction of mortality and morbidity.

There are major constraints on the acquisition of biomechanical data. Mechanisms of injury cannot be experimentally studied in humans. Volunteers are used within voluntary tolerance limits. Animals are used in more severe experiments to study physiological disruptions due to injury. Cadavers are used to study structural disintegration from severe experiments. More severe injury observations on humans are available from epidemiological observations of uncontrolled events or accidents; the validity of these observations for the purpose of developing protective strategies should be ascertained. This factor is a major distinguishing characteristic of human biomechanics from the usually more directly accessible endeavors of physics, chemistry, and engineering. Because of these constraints in the acquisition of biomechanical data and because such data are expensive to gather, the mutual sharing of such data among laboratories is extremely important and could be accomplished through the establishment of a national biomechanics data bank. However, since the development of a national facility would take time and would itself be extremely expensive, the group feels that the interim measure of standardizing among the several small existing data banks is needed. This would permit retrieval of

data from any small bank that is in a format common to the others in terms of nomenclature, unit of measure, anatomical coordinate system, and quality estimate. The common format would then permit collation of small bank data into the national bank with minimal difficulty when funding becomes available.

A recent National Research Council report details the national needs for critically evaluated physical and chemical data (2). Many of the observations of this report are directly applicable to the discipline of biomechanics. Of particular note is the observation. "Unreliable data can be worse than no data. Their use can lead to poorly conceived experiments, ineffective or inefficient manufacturing plants and a waste of both effort and resources" (p.3). The report details important examples of widely divergent published data requiring extensive critical evaluation for national use. Misinformation in the area of human biomechanics can also lead to design failure of protective systems with associated mortality and morbidity.

Other aspects of biomechanics data collection contrast sharply with the collection of physical and chemical data. The experimental subjects, humans and human surrogates, are inhomogeneous, vastly more complex, and more variable than are physio-chemical materials. The full range of required human biomechanical data can only be approached indirectly due to the severe constraints of human research. The fact that scientists, engineers, and technicians involved in the research and development effort come from widely disparate backgrounds, training, and disciplines inhibits recognition of common methodology and data goals. The historical development of data in biomechanics is relatively recent, dating primarily from World War II. The national research and development resources committed to this area are modest compared with the larger world of activity involved in collecting physical and chemical data.

As in the case of physical and chemical data, the benefit of a national data bank would be directly related to the quality of critical evaluation of available data. In addition to the inherent difficulties (2), there are additional confounding problems of indirect methods of investigation, complexity of subject matter and approaches, and a direct cost of mortality and morbidity from erroneous data.

The purpose of Working Group 87 has been to study the feasibility of establishing a computerized repository for all biomechanical data originating from the technical programs funded by U.S. government agencies. The bank would encourage standardization of research data that would, in turn, provide methods for accurate comparison, correlation, and analysis of data. This standardization is essential for at least three reasons:

(1) The biomechanical models developed using the data base could be used in predicting the kinematics and injury potential of the different force environments;
(2) The best methods of treating trauma resulting from these forces could be synthesized; and
(3) New technology to reduce the amount and possibility of trauma could be developed.

The Working Group was requested to determine:

- The approach, scope, and reasonable extent of a biomechanics data bank;
- The nature of the data to be included, e.g., format of submission, selection of type of experiments, definition of quantities, etc.;
- The desirable requirements for data storage and retrieval;
- Which government agencies, programs, and private institutions have the interest and the capability to provide input to and to use the data bank; and
- The approximate cost estimate of establishing and monitoring the data bank.

In order to delineate the different aspects of the above inquiries, the working group was divided into three subgroups.

The Materials and Compartmental Properties Subgroup was charged with examining the extent, availability, and format of the data bank with respect to humans and other animal species in the following areas:

- Geometrical and anthropometrical data;
- Stiffness and/or material properties data;
- Inertial property distribution data;
- Gross mechanical data for different compartments; and
- Failure criteria.

The Whole-Body Biomechanic Response Subgroup was charged with determining the scope, feasibility, and format of the dynamic test data in terms of human, dummy, cadaver, and nonhuman animal species in the following areas:

- Guidelines for comparison of whole-body system dynamic test data;
- Availability of data with respect to acceleration vector directions;
- The role of restraints and supports; and
- Data storage, retrieval, transmission, and analysis.

The Accidents and Injuries Subgroup was charged with studying the methods of quantifying the location and severity of injury and the format for displaying the accident and injury data in terms of cadaveric tests, clinical and pathological observation, and in vivo animal experiments. These include areas such as:

- New and/or modified autopsy procedures;
- Anatomical locators;
- Quantification of the severity of injury; and
- Correlations between the dynamic event parameters (The Whole-Body Biomechanic Response Subgroup) and injury severity.

FINDINGS AND RECOMMENDATIONS

It is the consensus of the working group that a national effort to collect biomechanics data of high quality and to make them available to government agencies and researchers active in this field is highly desirable and feasible. Although time constraints prohibited a detailed analysis of the cost effectiveness of such data collection, the group is convinced that the recent conclusions and cost estimates of the National Research Council's Committee on Data Needs (2) regarding the national requirements for critically evaluated data apply to biomechanics data. Data accumulation on biomechanics is not only restricted by funding and time constraints but also by the availability of accident data as well as ethical considerations with respect to animal and cadaveric tests. Therefore, optimal use and distribution of all available data to all researchers concerned are clearly desirable to justify such tests. The estimated cost, according to the National Research Council's report (2), of critical evaluation, compilation, and making such data generally available is less than 1 percent of original costs of obtaining the data, thus making such data compilation for biomechanics highly desirable and cost effective.

The group agreed that a compilation of biomechanics data would best be accomplished by the establishment of a national biomechanics data bank, which would collect and make generally available critically evaluated data to assist the following functions and to achieve the following objectives:

- Collection of biomechanic injury statistics;
- Evaluation of restraint systems and protective equipment;
- Validation of mathematical injury prediction models;
- Evaluation and interpretation of animal and cadaveric tests and their implications with respect to human injury;
- Establishment of injury safety standards; and
- Collection of quality tissue and compartmental property data for medical and protective engineering purposes.

The group agreed that such a national biomechanics data bank should be organized into the following three subareas:

(1) Materials and compartmental properties data;
(2) Whole-body biomechanic response data (human and human surrogates); and
(3) Accidents and injuries data.

A fourth subarea containing a collection of mathematical biomechanical models of general interest and usefulness was discussed but was not considered for immediate implementation and therefore will not be further discussed in this report.

According to this general outline, Working Group 87 organized into three subgroups to consider in more detail the objectives and potential realization of the three parts of the overall data bank. The conclusions and recommendations for the three subareas, which resulted from these efforts, are presented in Part 2 of this report.

Several basic conclusions and recommendations are applicable to all three areas and were agreed to by all working group members:

1. A national biomechanics data bank accessible to all government agencies, industry, and academic researchers is desirable for each of the subareas and is highly recommended for consideration to the agencies involved. Since interest in each subarea is understandably quite different for the different agencies, funding as well as physical location of the subareas of the national biomechanics data bank need not be limited to one agency. However, coordination of all subareas is essential and should be accomplished by a steering committee.

2. All data finally stored in a national biomechanics data bank should undergo critical peer review by competent experts for quality, accuracy, and completeness. Appropriate indicators for the degree of accuracy and completeness should be worked out for all subareas. However, it is better to err through accepting data of questionable value than to be too stringent and risk stifling the endeavor.

3. Realizing that organization and funding of a national biomechanics data bank might take time and is not achievable overnight, the working group foresees and recommends the growth of individual local data banks at different government agencies and research institutions. As far as possible and feasible, these local data banks should adhere to the quality standards, data requirements, data classification, and data format recommended by Working Group 87. Obviously, these recommendations will have to be amended by further studies of appropriate committees of scientists. Future potential submission of data from such local data banks to a generally accessible national data bank will be facilitated by adherence to coordinated voluntary guidelines and principles such as those outlined in this report. The group discovered the presence of and/or plans for several local biomechanical data banks at several research centers or government agencies and recommends the development of these existing local data banks as nuclei for a future national data bank.

4. Standardization of biomechanical coordinate systems defined by anatomical landmarks that can be easily identified and reproduced, standardization of response descriptions, standardization of injury terminology and standardization of classification will facilitate comparability of data. This should be supported by government agencies as well as the industrial and scientific communities. Appropriate committees of the American National Standards Institute as well as the International Standards Organization and other similar efforts of national and international organizations should be encouraged to

accelerate such work and should be supported through broader participation.

5. In view of the existence of several local data banks, and realizing that a full scale national data bank might be slow in developing, the group strongly recommends the immediate establishment of a national biomechanics data bank index containing information on the existence, content, availability, and format of all local data banks in the United States. This national index should contain indicators for quality, accuracy, and completeness. This national index could be established at minimal cost by one of the government agencies and could form the nucleus for the further development of the national biomechanics data bank.

6. It is recommended that the National Science Foundation or those government agencies primarily interested in the use of a national biomechanics data bank (the Department of Transportation, the Department of Defense, and the Department of Health and Human Services) continue to work toward the technical development and eventual partial or total funding of the efforts recommended by this working group.

REPORTS OF THE SUBGROUPS

DATA ON MATERIALS AND COMPARTMENTAL PROPERTIES

The Materials and Compartmental Properties Subgroup examined the extent, availability, and format of a national data bank with respect to humans and other animal species in the areas of:

- Geometric and anthropometric data;
- Basic material and compartmental properties data;
- Structural stiffness and damping data;
- Inertial distribution data; and
- Failure criteria.

DATA REQUIREMENTS

A first step in establishing a national biomechanics data bank would be to identify the data requirements, i.e., types of data that need to be stored. This should be followed by a search of existing data and recommendations for new data-gathering projects. During this search period, certain standards of quality should be formulated and the existing data should be judged against these standards.

Another preliminary step leading to the establishment of the data bank would be to outline precisely the data format and the data coding procedures. The guiding factors should be the minimization of the equipment and other costs and the maximization of the data input/output efficiency.

The subgroup recommends that both raw and reduced data be included in the data bank. The term "raw data" is defined as the direct individual measurements made during an experiment. Reduction and interpretation of raw data require careful and complete documentation. Documented raw data would make it possible for another researcher at a later date to reanalyze and reduce the original data in a form that may be entirely different from that of the researcher who originally submitted them.

The subgroup highly recommends a careful scientific review of the quality of all data submitted to the data bank.

OPERATIONAL REQUIREMENTS

The data should be submitted, stored, and distributed either in the form of written reports or, preferably, in computer records accompanied by written documentation.

In general, a person wishing to deposit a large quantity of experimental data should be requested to present the data in the form of a magnetic tape. This tape would be considered as a master tape and would be stored at the data bank with its documentation. A copy would be made for any person wishing to withdraw the data.

Such a data bank system entails certain operational and equipment requirements. A common data format and medium would be essential for efficient data handling. If the magnetic tape is chosen as the medium of communication, then the magnetic tape drives as well as the requisite computer systems must be available at all three sites -- namely, those of the data depositor, data bank, and data receiver.

MANAGEMENT REQUIREMENTS

The subgroup recommends that the technical direction of the entire data bank should be carried out by a scientific editorial board consisting of a chairman and three technical editors. These four members should be qualified scientific researchers, with current active involvement in biomechanics research. The chairman should have a record of distinguished research accomplishments.

Each of the three panels would be headed by one of the three technical editors. Each technical editor would recommend the structure, function, and membership of the panel. All data bank contributions would be scientifically reviewed and acted on by these panels with the help of external reviewers if appropriate.

COST REQUIREMENTS

Costs are of course involved in the management and actual operation of the data bank.

The subgroup believes that the members of the scientific editorial board would provide their services free of charge. The only costs involved would be those for meetings, which should be underwritten by an appropriate agency of the federal research establishment.

There should be a data bank staff for each panel consisting of a full-time researcher with a master's degree and a secretary/programmer. The salaries of these two staff members plus all related expenses would be provided by an appropriate federal agency. This support should not be provided at the expense of any present research programs but should come from new funds. The expense to data bank users would be slightly above direct cost.

SUMMARY AND MAJOR RECOMMENDATIONS

There is a need for a national biomechanics data bank, and it is unanimously recommended that such a bank should be established. The data bank would serve as a communication link among researchers working in this field. Major recommendations regarding the data on constituent materials and compartmental properties are listed below:

(1) Establishment of the data bank should emphasize development of data quality standards and formats.
(2) Both raw and reduced data should be included with proper documentation.
(3) Full scientific review of all data submitted to the data bank should be required.
(4) The data should be in the form of written reports or electronic records.
(5) A common data format and medium should be established for efficient data handling.

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DATA ON WHOLE-BODY BIOMECHANIC RESPONSE

The Whole-Body Biomechanic Response Subgroup examined the scope, feasibility, and format of the dynamic tests data in terms of humans, dummy, cadaver, and various animal species with respect to:

- Guidelines for comparison of whole-body system dynamic test data;
- The availability of data with respect to acceleration vector directions;
- The role of restraints and supports; and
- Data storage, retrieval, transmission, and analysis.

DATA REQUIREMENTS

The subgroup agrees that a need exists for a national data bank. The major concerns are the type of data that should be stored in a national data bank and the measures needed to ensure that the data contained therein are of high quality. If the data bank is to be given national status, only data of high quality should be accepted for storage. However, for the interim data banks that have been set up, such stringent controls may not be necessary. Alternatively, research laboratories and governmental agencies could maintain individual data banks using a uniform format, and potential users could be provided with a list of such banks and the data available from each source. Some members felt that it would take too long and cost too much to aim for a formalized national data bank and that the alternative approaches would be more efficient and practical.

The subgroup discussed rules under which data would be accepted for a national or interim data bank.

Peer Review. It was generally agreed that some form of peer review is necessary before any data set can be accepted for storage. Many problems associated with errors, mechanical format, and consistency could be checked by a computer and do not require manual or human intervention. Consistency checks could include order of magnitude and sign tests and variable identification. Peer review would thus consist of making a value judgment on the quality and validity of the data and the appropriateness of the methodology used to acquire the data.

Gradation of Data. The review process could be used to assign a level of quality to each data set as a guide to the user. This mechanism would give the bank a degree of flexibility in accepting data with a wider range of quality. Users would be advised of and cautioned about the proper use of the assigned quality level.

Data Identification. Generic identification of all data should be provided, including type, units used, error estimates, and other information regarding data processing procedures, location of sensors, and methodology used. These requirements imply that a certain amount of processing would be necessary before the data could be entered into the data bank. The subgroup felt that this preprocessing should be kept to a minimum and that information derivable from the data should be left to the user. For example, if linear acceleration data are provided, velocity information is not necessary. Each data set should also be accompanied by a bibliographic identification of author(s), institution, current address, data, and journal or report reference to the data, if published.

Suitable Types of Data. The subgroup recommends that data from the following types of tests on humans and human surrogates should be considered for the national data bank: horizontal sled and vehicular impacts; vertical sled tests; off-axis impacts; wind-blast tests; and free fall impacts. For each of these tests, two types of data would generally be acquired. They can be divided into mechanical response and physiological response data. Details of these parameters and test conditions are available from CHABA.

Anatomically Based Coordinate Systems. To facilitate comparability of biomechanical data, a clear definition and, preferably, standardization of an antomically based coordinate system for each body segment are necessary. An ad hoc committee of the International Workshop on Human Subjects for Biomechanical Research, chaired by Daniel J. Thomas, has proposed coordinate systems for the head, neck, and pelvis. These systems can be adopted for use by contributors to the data bank. Padgaonkar (3) has proposed coordinate systems for the upper and lower extremities that could also be used conveniently. The recommendation of the ad hoc committee and the coordinate systems for the upper and lower extremities are available from CHABA.

It would not be mandatory for a contributor to use these coordinate systems. They are recommended because of the general accessibility of landmarks to palpation as well as their visibility in X-rays. However, all data should be referred to by a consistent set of body-fixed coordinate systems that can be identified and reproduced in test subjects in any laboratory.

The terminology used to define input acceleration conditions is often a source of confusion. A definition of the symbols generally used to describe these conditions is available from CHABA.

OPERATIONAL REQUIREMENTS

In general, all data stored in the data bank should be in digital form. Digital magnetic tapes would be the primary mode of storage.

The data bank should be equipped with 7-track and 9-track tape drives capable of handling tapes recorded at high densities. Redundant or backup tapes should be required in the event that the primary tape is destroyed or lost. To prevent deterioration of the tape or the magnetic encoding, a new set of backup tapes could be made up at predetermined time intervals. If analog data of exceptional quality become available, consideration should be given to storing such data on analog tape or to digitizing the data.

An index or code book should be published to provide a listing of all data sets and their formats in the data bank and instructions for access to these data. Requests should be made via telephone using any teletype or terminal. The data would be copied onto tape and sent by mail to the requestor.

COST REQUIREMENTS

The maintenance of any data bank would involve a recurring cost for personnel, computer, and supplies. An estimate of an annual budget is yet to be made. The data bank is not expected to be self-supporting since the number of users is unpredictable but expected to be small. All users should pay a service charge to cover the cost of individual requests.

PRELIMINARY DATA BASE

A thoracic injury data base management and modeling system is under development for the National Highway Traffic Safety Administration (NHTSA). A paper describing the system is available from CHABA.

SUMMARY AND MAJOR RECOMMENDATIONS

(1) A need exists for a national biomechanical data bank with rules for accepting data.
(2) Peer review of the data is necessary.
(3) The data should be gradated in terms of accuracy and completeness.
(4) Identification of data should be required (the type of data to be stored is listed above).
(5) An antomically based coordinate system should be followed.
(6) Data format should be generally in digital form.
(7) An index or code book of data sources should be made available.

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DATA ON ACCIDENTS AND INJUPIES

The Accidents and Injuries Subgroup studied the methods of quantifying the location and severity of the accident and injury data in terms of cadaveric tests, clinical and pathological observations, and in vivo animal experiments and considered a format for displaying these data. These include areas such as:

- New and modified autopsy procedures;
- Anatomical locators;
- Quantification of the severity of injury; and
- Correlations between the dynamic event parameters (The Whole-Body Biomechanic Response Subgroup) and injury severity.

DATA REQUIREMENTS

Data in a national biomechanics accidents and injuries data bank should include injury descriptions from:

- Aircraft accidents;
- Aircraft escape maneuvers, including seat ejection, windblast, and parachute shock;
- Surface traffic accidents, including motorcyles and pedestrians;
- Sports accidents;
- Industrial and home accidents;
- Suicides and homicides; and
- Experiments with animals and human cadavers.

It should also include injury tolerance data from:

- Noninjury-level experiments with human volunteers and animal test subjects.

Information recorded in each case entry should include the injury event as well as the injury. The data should be classified according to type of accident and impact and should include an accuracy evaluation.

Injury Record. The injury description should contain the following:

- Anatomical location of injury;
- Injury name;
- Quantitative severity measures (based on size of lesion or degree of disability);

- Anatomical description of subject (including species, age, weight, body position, standardized anthropometric data, etc.);
- CT scan data before and after event, if available;
- Any special descriptive comments by investigator which add to the understanding of the injury, but which do not fit into standard record categories.

Event Record. When available, the following information should be included in the event record:

- Forces or pressures, either on the whole body or on individual segments, if known (a cross-reference to the recorded time-dependent data should be included for experimental events);
- Direction and point of application of force or pressure;
- Impact velocity, if applicable;
- Resulting accelerations of the injured body segment;
- Kinematic response measures of the injured body segments (displacements/rotations);
- Description of the restraint system or protective devices, if applicable, including condition of device after event; and
- Description of objects impacted (including before and after impact).

Data Classification. To facilitate retrieval of similar record groups, the data should be classified. The following categories for classification are suggested:

- Type of accident (see list under Data Requirements above); and
- Type of impact--single or multiple impact and region of body involved.

Data Evaluation. An estimate of the record reliability should be supplied for potential users of the bank. This could be accomplished by including the following:

- Description of methodology--precise and concise description of the method used in obtaining the data, indicating the data source as accident record, autopsy report, conventional X-ray, CT scans, etc.;
- Accuracy of measurement--use percentage or confidence levels to estimate the accuracy of accident description, accuracy of measurement techniques in experiments, and accuracy with which injury is assessed; and
- Knowledge of the dynamic input producing injury--known, computed, estimated, and unknown.

OPERATIONAL REQUIREMENTS

A standardized format for data should be developed, designed to facilitate data storage and retrieval, permit comparison of one record with another, minimize amount of data stored, and minimize costs.

The injury record should list the injury name, anatomical location, and severity grade or degree of disability (4). Terminology could be selected, or the Standardized Nomenclature of Pathologists (SNOP) could be used. If the injury and locator names are used direc-

tly, the appropriate conversion to digital form should be made in the computer. A case identification number, subject description, and abbreviated injury scale should also be included. This injury record standardization would require the establishment of the following:

- autopsy protocols (5 and 6);
- clinical tests for assessing disability;
- reporting forms for the autopsy and clinical data (5 and 7);
- nomenclature (injury names and anatomical locators)--SNOP or some other standard terminology may be selected (4); and
- severity grades for injury and disability in addition to the AIS (4).

SUMMARY AND MAJOR RECOMMENDATIONS

(1) A data bank of accident and injury information is not just feasibile--it could exist in the near future.
(2) Data on accidents and injuries from sports and vehicular accidents, falls, and experimentally produced injuries in animals and cadavers should be stored.
(3) Guidelines for reviewing and classifying data should be formulated.
(4) A standard recording format of lesions should include clinical test for injury and disability in patients and injury name, anatomical location, and autopsy protocol in cadavers and experimental animals.
(5) Functional correlations between accident events and injury data form the major thrust of the subgroup's data base.

Already injury information in digital form is being collected by the Department of Transportation, the Navy Safety Center, and major hospitals. Also, the Aerospace Medical Research Laboratory of the Air Force has initiated plans for the establishment of a biomechanics data bank, starting with acceleration exposure data from human subjects. The supply of data is abundant, since trauma is a major cause of death. The task is to organize the data so that they can be compared, processed, and utilized to the best advantage.

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The major source of mortality and morbidity of the young adult population in industralized nations is due to impact acceleration from vehicular accidents. One strategy to reduce the mortality and morbidity is the use of protective devices to limit the loads applied to human occupants. The main thrust of a national biomechanics data bank at this time is toward biomechanical and injury data judged to be important for the reduction of mortality and morbidity. Because biomechanical data are expensive to gather, the mutual sharing of such data among laboratories is extremely important and could be accomplished through the establishment of a national biomechanics data bank. However, since the development of a national facility would take time and would itself be extremely expensive, the group feels that the interim measure of standardizing among the several small existing data banks is needed. This would permit retrieval of data from any small bank that is in a format common to the others in terms of nomenclature, units of measure, anatomical coordinate systems, and quality estimates. The common format would then permit eventual collation of small bank data into the national bank with minimal difficulty.

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Security Classification

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